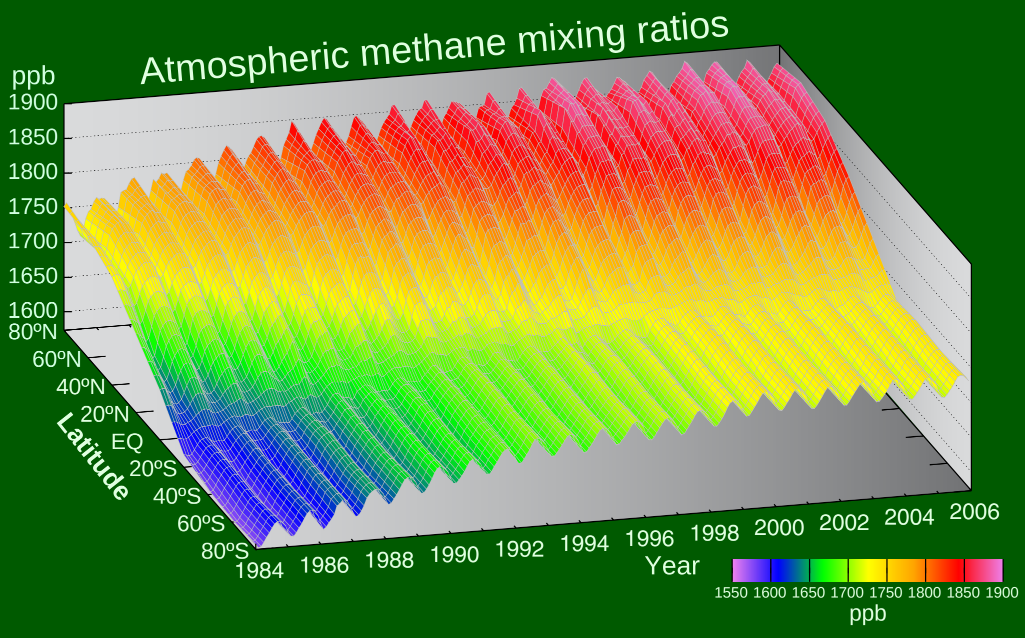
WMO
Greenhouse Gas Bulletin

The State of Greenhouse Gases in the Atmosphere Using Global Observations through 2005



Three-dimensional representation of the zonally-averaged latitudinal distribution of atmospheric methane (CH_4) mixing ratios for the period 1984-2005. Mixing ratios are given in parts per billion (ppb). A mixing ratio of 1800 ppb, for example, means that among 1 billion air molecules one will find 1800 CH_4 molecules.

Executive summary

The latest analysis of data from the WMO-GAW Global Greenhouse Gas Monitoring Network shows that the globally averaged mixing ratios of carbon dioxide (CO_2) and nitrous oxide (N_2O) have reached new highs in 2005 with CO_2 at 379.1 ppm and N_2O at 319.2 ppb. The mixing ratio of methane (CH_4) remains unchanged at 1783 ppb. These values are higher than those in pre-industrial times by 35.4%, 18.2% and 154.7%, respectively. Atmospheric growth rates in 2005 of these gases are consistent with recent years. Methane growth has slowed during the past decade. The recently introduced NOAA Annual Greenhouse Gas Index (AGGI) shows that from 1990 to 2005 the atmospheric radiative forcing by all long-lived greenhouse gases has increased by 21.5%.

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Global Atmosphere Watch

Overview

This is the second of a series of WMO-GAW Annual Greenhouse Gas Bulletins. Each year, these bulletins will report the latest trends and atmospheric burdens of the most influential, long-lived greenhouse gases; carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), as well as a summary of the contributions of the lesser gases. These three major gases alone contribute about 88% of the increase in radiative forcing of the atmosphere by changes in long-lived greenhouse gases occurring since the beginning of the industrial age (~1750).

The Global Atmosphere Watch (GAW) programme of the World Meteorological Organization (WMO) promotes systematic and reliable observations of the global atmospheric environment, including measurements of CO_2, CH_4, N_2O, and other atmospheric gases. Sites where some or all of these gases are monitored are shown in Figure 1. The measurement data are reported by participating countries and archived and distributed by the World Data Centre for Greenhouse Gases (WDCGG) at the Japan Meteorological Agency (JMA).

Statistics on the present global atmospheric abundances are given in Table 1. They have been increasing in

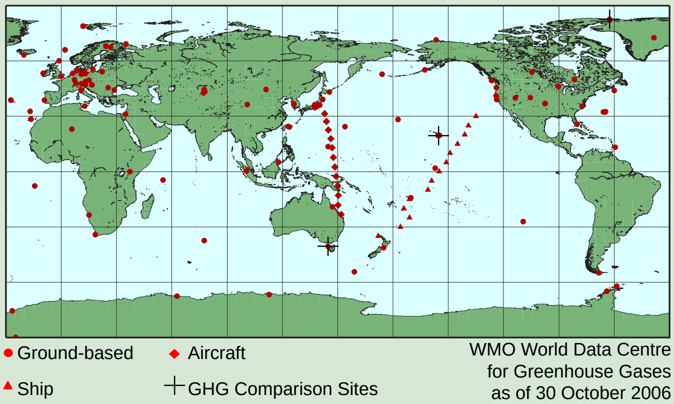

Figure 1. The WMO-GAW global greenhouse gas network for carbon dioxide. The network for methane is similar to this.

Table 1. Global abundances of key greenhouse gases as averaged over the twelve months of 2005 as well as trends from the WMO-GAW global greenhouse gas monitoring network.

	CO_2 (ppm)	CH_4 (ppb)	N_2O (ppb)
Global abundance in 2005	379.1	1783	319.2
2005 abundance relative to year 1750	135.4%	254.7%	118.2%
2004-05 absolute increase	2.0	0	0.6
2004-05 relative increase	0.53%	0.0%	0.19%
Mean annual absolute increase during last 10 years	1.9	2.8	0.74

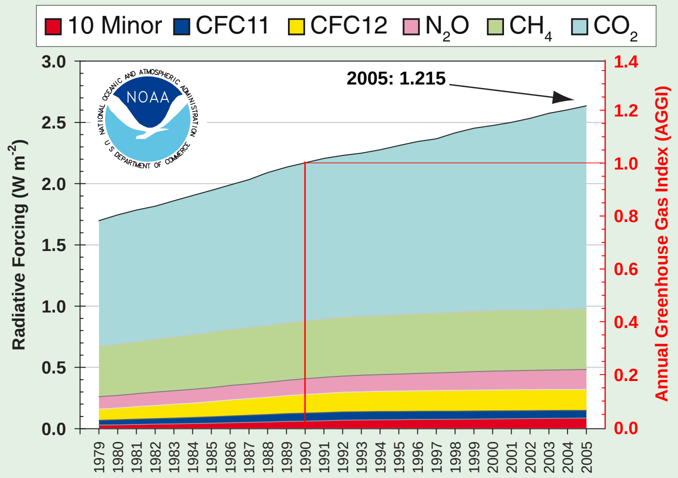

Figure 2. Changes in atmospheric radiative forcing by long-lived greenhouse gases and the 2005 NOAA Annual Greenhouse Gas Index (AGGI).

the atmosphere since the beginning of the industrial age. Water vapour is a natural component of the climate and weather system that is indirectly affected by human activities through changes in temperature, land surface characteristics and aerosol effects on clouds. This Bulletin focuses on those greenhouse gases that are directly influenced by human activities and that are generally much longer lived in the atmosphere than water vapour.

According to the newly released NOAA Annual Greenhouse Gas Index (AGGI), the total radiative forcing by all long-lived greenhouse gases has increased by 21.5% since 1990. The AGGI increased by 1.25% from 2004 to 2005 (see Figure 2). (http://www.cmdl.noaa.gov/aggi/).

Carbon Dioxide (CO_2)

CO_2 is the single most important infrared absorbing, anthropogenic gas in the atmosphere and is responsible for 62% of the total radiative forcing of Earth by long-lived greenhouse gases and over 90% of the increase in radiative forcing in the past decade. For about 10,000 years before the industrial revolution, the atmospheric abundance of CO_2 was nearly constant at ~280 ppm (ppm = number of molecules of the greenhouse gas per million molecules of air). This abundance represented a balance among large seasonal fluxes (on the order of 100 Gigatonnes (Gt) of carbon per year) between the atmosphere and biosphere (photosynthesis and respiration) and the atmosphere and the ocean (physical exchange of CO_2). Since the late 1700s, atmospheric CO_2 has increased by 35.4%, primarily because of emissions from combustion of fossil fuels (currently about 7 Gt carbon per year) and, to a lesser extent, deforestation (0.6-2.5 Gt carbon per year). High-precision measurements of atmospheric

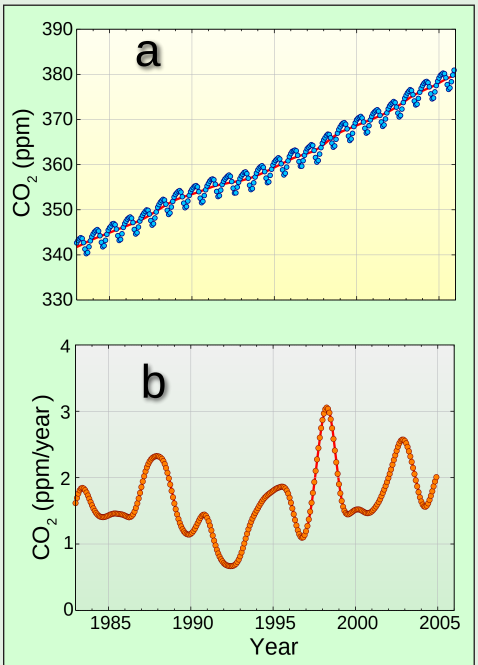

Figure 3. Globally averaged CO_2 (a) and its growth rate (b) from 1983 to 2005.

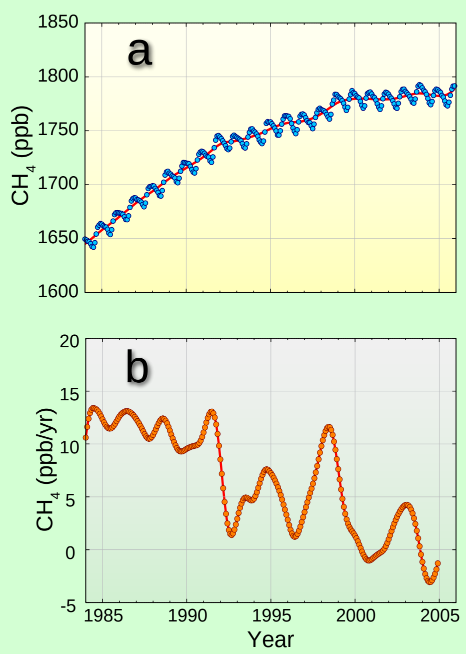

Figure 4. Globally averaged CH_4 (a) and its growth rate (b) from 1984 to 2005.

CO_2 beginning in 1958 show that the average increase of CO_2 in the atmosphere corresponds to ~55% of the CO_2 emitted by fossil fuel combustion. The remaining fossil fuel-CO_2 has been removed from the atmosphere by the oceans and the terrestrial biosphere. Globally averaged CO_2 in 2005 was 379.1 ppm and the increase from 2004 to 2005 was 2.0 ppm (Figure 3).

Methane (CH_4)

Methane contributes about 20% of the direct radiative forcing due to long-lived greenhouse gases affected by human activities. Its chemistry also indirectly affects climate by influencing tropospheric ozone and stratospheric water. Methane is emitted to the atmosphere by natural processes (~40%, e.g., wetlands and termites) and anthropogenic sources (~60%, e.g., fossil fuel exploitation, rice agriculture, ruminant animals, biomass burning, and landfills); it is removed from the atmosphere by reaction with the hydroxyl radical (OH) and has an atmospheric lifetime of ~9 years. Before the industrial era, atmospheric methane was at ~700 ppb (ppb = number of molecules of the greenhouse gas per billion (10^9) molecules of air). Increasing emissions from anthropogenic sources are responsible for the factor of 2.5 increase in CH_4. The cycling of methane, however, is complex and managing its atmospheric burden requires an understanding of its emissions and its budget of sources and sinks. Globally averaged CH_4 in 2005 was 1783 ppb, with virtually no increase observed since 2004 (Figure 4). By contrast, methane was increasing by up to 13 ppb per year during the late 1980s. The average growth rate has been around 3 ppb per year over the past ten years.

Nitrous Oxide (N_2O)

Nitrous oxide (N_2O) contributes about 6% of the total radiative forcing from long-lived greenhouse gases. Its atmospheric abundance prior to industrialization was 270 ppb. N_2O is emitted into the atmosphere from natural and anthropogenic sources, including the oceans, soil, combustion of fuels, biomass burning, fertiliser use, and various industrial processes. One-third of its total emissions is from anthropogenic sources. It is removed from the atmosphere by photochemical processes in the stratosphere. Globally averaged N_2O during 2005 was 319.2 ppb, up 0.6 ppb from the year before (Figure 5). The mean growth rate has been 0.74 ppb per year over the past 10 years.

Other Greenhouse Gases

The ozone depleting chlorofluorocarbons (CFCs) also contribute to the radiative forcing of the atmosphere. Their overall contribution to the global radiative forcing is significant (12% of the total; http://www.noaanews.noaa.gov/stories2005/s2512.htm). While atmospheric CFCs are now decreasing slowly, some of the CFCs still have a serious impact on the atmospheric greenhouse effect. Some species such as hydrochlorofluoro-

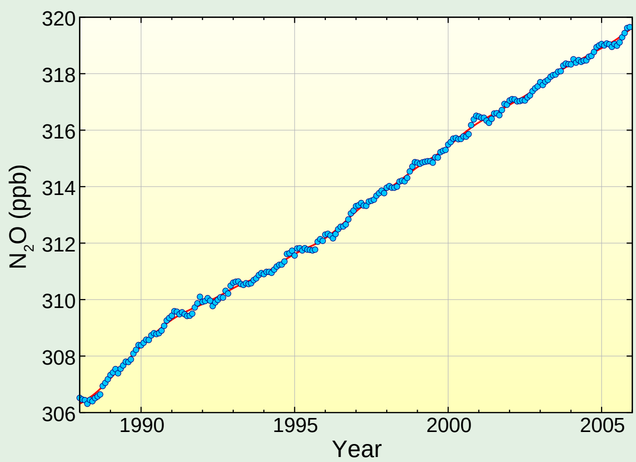

Figure 5. Changes in monthly mean mixing ratios of N_2O from 1988 to 2005.

carbons (HCFCs), which are strong infrared absorbers, are increasing at rapid rates, although low in abundance. Ozone in the troposphere does not have a long lifetime, but it has an atmospheric greenhouse effect that is comparable to those of the CFCs. Although tropospheric ozone is important for the atmospheric greenhouse effect, it is difficult to estimate the global distribution and trend due to its very uneven geographic distribution. All the gases mentioned here are also monitored as part of the WMO-GAW network.

Distribution of the bulletins

The Secretariat of the World Meteorological Organization (WMO) prepares and distributes Bulletins in cooperation with the World Data Centre for Greenhouse Gases at the Japan Meteorological Agency and the GAW Scientific Advisory Group for Greenhouse Gases, with the assistance of the NOAA Earth System Research Laboratory. The Bulletins are available through the Global Atmosphere Watch programme web page at http://www.wmo.int/web/arep/gaw/gaw_home.html, and on the home pages of WDCGG (http://gaw.kishou.go.jp/wdcgg.html) and the NOAA Carbon Cycle Greenhouse Gases Group (http://www.cmdl.noaa.gov/ccgg).

Acknowledgements and links

Forty-four countries are registered in GAWSIS as having contributed CO_2 data to the GAW WDCGG. Of these, many are associated with the NOAA global flask sampling network. NOAA-supported sites represent approximately 70% of the countries submitting data to GAW. The rest of the network is maintained by Australia, Canada, China, Japan and many European countries (see the national reports in GAW Report #161 from the Sept. 2003 Experts Meeting). All of the WMO Global Atmosphere Watch (GAW) monitoring stations contributing to the data used in this Bulletin are shown on the map (Figure 1) and listed in the List of Contributors on the WDCGG web page at (http://gaw.kishou.go.jp/wdcgg.html). They are also described in the GAW Station Information System (GAWSIS) (http://www.empa.ch/gaw/gawsis/) operated by Switzerland.

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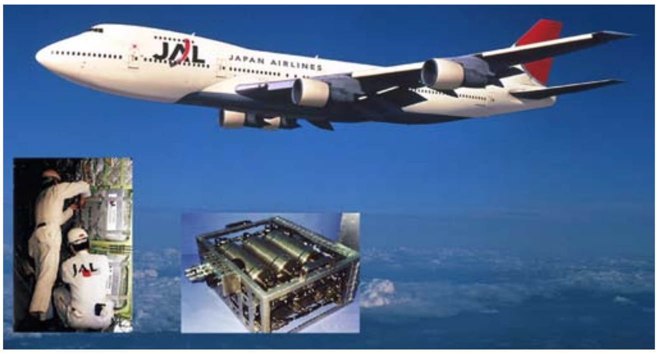
2. World Data Centre for Greenhouse Gases, Japan Meteorological Agency, Tokyo.
   E-mail: wdcgg@hq.kishou.go.jp
   Web site: http://gaw.kishou.go.jp/wdcgg.html

Selected GAW global observatories

Dr. Neil Trivett Global Atmosphere Watch Observatory, Alert, Canada

South Pole Atmospheric Research Observatory



Airborne measurements are done from this airliner of Japan Airlines

Measurements of greenhouse gases are taken from Cap Victor as it traverses the Pacific Ocean.